(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 April 2001 (19.04.2001)

PCT

(10) International Publication Number
WO 01/27920 A1

(51) International Patent Classification[7]: G11B 17/038, 17/02

(21) International Application Number: PCT/US00/27621

(22) International Filing Date: 5 October 2000 (05.10.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/158,840 12 October 1999 (12.10.1999) US

(71) Applicant: SEAGATE TECHNOLOGY LLC [US/US]; 920 Disc Drive, Scotts Valley, CA 95066 (US).

(72) Inventors: JOSHI, Shantanu, Dattatrey; 2450 Airport Road, Apt. #E243, Longmont, CO 80503 (US). DURRUM, Thomas, M.; 1311 Birch Street, Broomfield, CO 80020 (US). THOMPSON, Daniel, Scott; 1572 Mayfield Lane, Longmont, CO 80501 (US). STAGGERS, James, Rex; 401 Lakritz, Berthoud, CO 80513 (US). BEATTY, Paul, Allison; 3206 Lake Park Way #306, Longmont, CO 80503 (US).

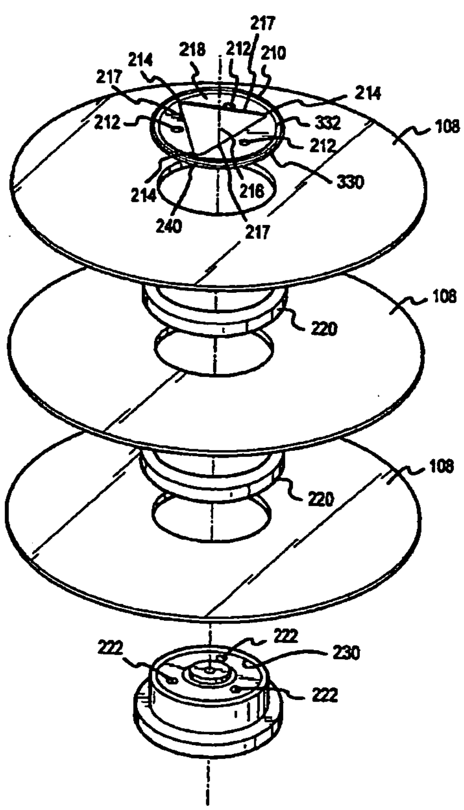
(74) Agents: BRUESS, Steven, C.; Merchant & Gould P.C., P.O. Box 2903, Minneapolis, MN 55402-0903 et al. (US).

(81) Designated States *(national)*: CN, DE, GB, JP, KR, SG.

Published:
— *With international search report.*

[Continued on next page]

(54) Title: UNIFORM LOADING DAMPED DISC CLAMP



(57) Abstract: The performance of a leaf spring disc clamp can be enhanced by utilizing a roughly triangular shape for the center aperture. Such a disc clamp exhibits a substantially more uniform distribution of clamping force on the data disc and thereby reduces the deformation of the disc. It has further been determined that a stiffening rib located adjacent to the rim portion which contacts the data disc also leads to more uniform distribution of clamping force. Lastly, vibrations in a leaf spring disc clamp from external shocks or drive operation can be reduced utilizing a dampening ring of visco-elastic material. The dampening ring can be fastened to the surface of the disc clamp or placed within a rib on the disc clamp.

WO 01/27920 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

UNIFORM LOADING DAMPED DISC CLAMP

Field of the Invention

This application relates generally to disc drives and more particularly to a clamping mechanism for retaining one or more data storage disc on a spin motor.

Background of the Invention

Disc drives are data storage devices that store digital data in magnetic form on a rotating storage medium on a disc. Modern disc drives comprise one or more rigid discs that are typically coated with a magnetizable medium and mounted on the hub of a spin motor for rotation at a constant high speed. Information is stored on the discs in a plurality of concentric circular tracks typically by transducers ("heads") mounted to an actuator assembly for movement of the heads relative to the discs. During a write operation, data is written onto the disc track and during a read operation the head senses the data previously written on the disc track and transfers the information to the external environment. Critical to both of these operations is the accurate positioning of the head over the center of the desired track.

The heads are each mounted via flexures at the ends of actuator arms that project radially outward from the actuator body or "E" block. The actuator body typically pivots about a shaft mounted to the disc drive housing adjacent to the outer extreme of the discs. The pivot shaft is parallel to the axis of rotation of the spin motor and the discs, so that the heads move in a plane parallel to the surfaces of the discs.

Typically, such actuator assemblies employ a voice coil motor to position the heads with respect to the disc surfaces. The voice coil motor typically includes a flat coil mounted horizontally on the side of the actuator body opposite the actuator arms. The coil is immersed in a vertical magnetic field of a magnetic circuit comprising one or more permanent magnets and vertically spaced apart magnetically permeable pole pieces. When controlled direct current (DC) is passed through the coil, an electromagnetic field is set up which interacts with the magnetic field of the magnetic circuit to cause the coil to move in accordance with the well-known Lorentz relationship. As the coil moves, the actuator body pivots about the pivot

shaft and the heads move across the disc surfaces. The actuator thus allows the head to move back and forth in an arcuate fashion between an inner radius and an outer radius of the discs.

Modern disc drives typically include one or more discs mounted to the spin motor. Spacers are used to provide the separation between discs necessary for the actuators arms to movably locate the heads in relation with the disc surfaces. The discs and spacers collectively form a disc stack assembly, or disc pack, that is mounted on the spin motor hub and held together with a leaf spring disc clamp.

Disc clamps can be either stamped or milled. While milled clamps are more rigid and less prone to deflecting the abutting disc surface, they are relatively expensive to produce. Consequently, stamped leaf spring disc clamps, which are substantially less expensive, have become popular. The clamp is typically a circular spring-steel, sheet metal structure having a central portion and a rib portion at or near the outside diameter of the clamp, with an annular rib formed in the rim portion of the clamp. The central portion of the leaf spring disc clamp has a partial aperture that is bent or deflected toward the center of the clamp, forming a leaf spring above the level of the annular rib, and includes a plurality of screw holes spaced symmetrically about the central portion of the clamp. The screws used to mount the disc clamp springingly bend and deflect the central portion of the clamp toward the upper surface of the motor spindle as the screws are tightened, thereby forcing the annular rib into firm contact with the uppermost disc surface and applying a clamping force to the disc stack.

This type of disc clamp is not without problems. The disc clamp is secured with a plurality of screws, typically 3, circumferentially spaced around the center of the clamp. The majority of the clamping force is exerted by the rib portion adjacent the screw locations, with a significantly reduced level of clamping force, and often no clamping force at all, exerted by the rib portion between the screw locations. This variation in clamping force can mechanically distort the discs in a phenomenon sometimes referred to as "potato chipping," meaning that the portions of the disc nearest the clamp screws are displaced further than the portions of the disc between the screws.

Disc drives are subject to external shocks and must be designed to meet certain specified shock requirements. The non-uniform clamping force from current disc clamp design requires higher clamping forces to prevent disc slip from external shocks to the disc drive and the higher clamping forces increase the severity of "potato chipping."

One solution to "potato chipping" is to increase the number of mounting screws used to secure the disc clamp to the spin motor hub. As more screws are used and are spaced closer together, the discrepancy in clamping force is reduced but not eliminated. A disadvantage of this approach is that the use of additional screws complicates the manufacturing and assembly process and increases costs.

Mechanical distortion of the disc surface can, in turn, lead to undesirable variations in the read/write signals detected and written by the heads of the disc drive. Since the heads will fly at varying heights around the circumference of the disc while attempting to follow a distorted disc, the signals used to read and write data on the discs may be inadequate to ensure reliable data storage and recovery.

Another problem encountered with the current disc clamps is the transfer of vibrations from the discs to the clamp. Current disc clamps do not dampen vibrations from shocks to the disc drive and the vibrations can resonate in the disc clamp or set it to "ringing." This "ringing" then is transferred to the discs. Vibrations in the discs are an additional source of undesirable variations in the read/write signals detected and written by the heads.

Accordingly there is a need for a mechanism that would more evenly distribute the force applied to the disc surface from the disc clamp and also dampen vibrations in the disc clamp.

Summary of the Invention

Against this backdrop the present invention has been developed. The performance of a disc clamp can be enhanced by utilizing a roughly triangular shape for the center aperture. Such a disc clamp exhibits a substantially more uniform distribution of clamping force and reduces the "potato chipping" of the disc. It has further been determined that a stiffening rib located adjacent to the rim portion which contacts the data disc also leads to more uniform distribution of clamping

force. The invention has advantages over other mechanisms in that it does not require additional screws, other parts, or a significant change in the manufacturing process.

Accordingly, an aspect of the invention is found in utilizing a roughly triangular shaped central aperture in a disc clamp fastened with three screws to distribute the clamping force more uniformly on the disc.

Another aspect of the invention is providing a stiffening rib adjacent to the annular contract surface to increase the stiffness of the contact surface and more uniformly distribute the clamping force.

Yet another aspect of the invention is fastening a dampening ring to the disc clamp to reduce the amount of vibration in the disc clamp.

These and various other features as well as advantages which characterize the present invention will be apparent from a reading of the following detailed description and a review of the associated drawings.

Brief Description of the Drawings

FIG. 1 is a plan view of a disc drive incorporating a preferred embodiment of a disc clamp in accordance with the present invention showing the primary internal components.

FIG. 2 is an exploded view of an exemplary disc pack assembly utilizing a disc clamp in accordance with a preferred embodiment of the present invention.

FIG. 3 is a separate perspective view of a preferred embodiment of the disc clamp in accordance with the present invention.

FIG. 4 is a graphical representation of the clamping force distribution of the disc clamp shown in FIG. 3.

FIG. 5 is a plan view of a preferred embodiment of a disc clamp in accordance with the present invention showing the optimal range of sizes of a central aperture.

FIG. 6 is a cross-sectional view of the disc clamp shown in FIG. 3.

FIG. 7 is a cross-sectional view of another preferred embodiment of the present invention having a vibration dampening ring installed.

Detailed Description

A disc drive **100** constructed in accordance with a preferred embodiment of the present invention is shown in FIG. **1**. The disc drive **100** includes a base **102** to which various components of the disc drive **100** are mounted. A top cover **104**, shown partially cut away, cooperates with the base **102** to form an internal, sealed environment for the disc drive in a conventional manner. The components include a spindle motor **106** that rotates one or more discs **108** at a constant high speed. Information is written to and read from tracks on the discs **108** through the use of an actuator assembly **110**, which rotates during a seek operation about a bearing shaft assembly **112** positioned adjacent the discs **108**. The actuator assembly **110** includes a plurality of actuator arms **114** which extend towards the discs **108**, with one or more flexures **116** extending from each of the actuator arms **114**. Mounted at the distal end of each of the flexures **116** is a head **118**, which includes an air bearing slider enabling the head **118** to fly in close proximity above the corresponding surface of the associated disc **108**.

During a seek operation, the track position of the heads **118** is controlled through the use of a voice coil motor (VCM) **124**, which typically includes a coil **126** attached to the actuator assembly **110**, as well as one or more permanent magnets **128** which establish a magnetic field in which the coil **126** is immersed. The controlled application of current to the coil **126** causes magnetic interaction between the permanent magnets **128** and the coil **126** so that the coil **126** moves in accordance with the well-known Lorentz relationship. As the coil **126** moves, the actuator assembly **110** pivots about the bearing shaft assembly **112**, and the heads **118** are caused to move across the surfaces of the discs **108**.

The spindle motor **106** is typically de-energized when the disc drive **100** is not in use for extended periods of time. The heads **118** are moved over park zones **120** near the inner diameter of the discs **108** when the drive motor is de-energized. The heads **118** are secured over the park zones **120** through the use of an actuator latch arrangement **122**, which prevents inadvertent rotation of the actuator assembly **110** when the heads are parked.

A flex assembly **130** provides the requisite electrical connection paths for the actuator assembly **110** while allowing pivotal movement of the actuator assembly **110** during operation. The flex assembly **130** includes a printed circuit board **132** to which head wires (not shown) are connected; the head wires being routed along the actuator arms **114** and the flexures **116** to the heads **118**. The printed circuit board **132** typically includes circuitry for controlling the write currents applied to the heads **118** during a write operation and a preamplifier for amplifying read signals generated by the heads **118** during a read operation. The flex assembly **130** terminates at a flex bracket **134** for communication through the base deck **102** to a disc drive printed circuit board (not shown) mounted to the bottom side of the disc drive **100**.

The discs **108** are secured to the hub **230** of a spin motor **106** in spaced-apart fashion. As illustrated in FIG. **2**, three discs **108** are alternatively stacked together with spacers **220** that provide the vertical spacing necessary for actuator assembly function (described hereinafter). The stacked set of discs **108** and spacers **220** are mounted to the spin motor **106** via the disc clamp **210**. The typical disc clamp **210** is disc shaped having an outer rim portion, a sheet metal body, and a central spring portion forming a leaf-spring type disc clamp. Any combination of discs **108** and spacers **220**, along with a disc clamp **210**, can be referred to as a disc assembly or disc pack. Preferably, three mounting screws (not shown) are used to secure disc clamp the **210** to the spin motor hub **230** using threaded bores **222** in the hub **230**.

FIG. **2** shows the disc clamp **210** according to a preferred embodiment of the present invention. The disc clamp **210** has a bowed central leaf spring portion **218** that has a triangular central aperture **216**. The clamp **210** also has an annular rim portion **240** having an annular contact rib **330** and a concentric annular stiffening portion **332** adjacent to the rib (better seen in the sectional views of FIGS. **6** and **7**). As described hereinafter, the annular rib **330** preferably provides the contact surface between the disc clamp **210** and the upper surface of the uppermost disc **108**. The adjacent stiffening portion **332** is a concentric rib **334** adjacent to the annular contact rib **330**.

The disc clamp **210**, as shown in FIG. **3**, is a generally circular disc shaped body having a central portion **218** and a peripheral annular rim portion **240** forming

an annular rib **330** and a concentric annular stiffening portion **332** adjacent to the rib **330**. The central portion **218** has a triangular central aperture **216** therethrough and screw mounting holes **212** equidistantly spaced around the central aperture **216** of the disc clamp **210**. The screw mounting holes **212** each receives a screw (not shown) to fasten the disc clamp **210** to the hub **230** of the spin motor **106**. The disc clamp **210** further includes a corner **214** between every two adjacent screw-mounting holes **212** within the central portion **218** of the disc clamp **210**. Each of the corners **214** of the central aperture **216** is rounded.

The triangular shape of the central aperture **216** enhances the equalization of the clamping force exerted by the annular rib **330** against the disc **108**, which reduces "potato chipping" of the disc **108**, i.e. the disc clamp **210** reduces the distortion of the disc **108** due to clamping forces. A graphical representation of the results of a computer model of the distribution of clamping force of a disc clamp **210** with a triangular shaped central aperture **216** is shown in FIG. **4**. The magnitude of the clamping force about the annular rib **330** is shown by the height of peaks superimposed on the view of the disc clamp **210**. The higher the peak, the greater the clamping force at that of the annular ring **330**. FIG. **4** shows that the triangular shape of the central aperture **216** performs the equalizing function in two ways. First, the triangular shaped aperture **216** more uniformly distributes the clamping force about the annular contact rib **330** than a typical disc clamp. Second, because the clamping force is more uniformly distributed, the disc clamp **210** reduces the amount of clamping force necessary to prevent disc **108** slip and meet a specified shock requirement. This, in turn, further reduces the force applied to the disc **108** and further reduces disc distortion attributable to the clamp **210**.

Computer modeling further determined the optimum operable range of for the triangular shaped aperture **216**. For a disc clamp **210** of typical size (i.e. outer diameter of 1.22 inches and an engagement surface or contact diameter of 1.125 inches), an optimum range for the triangular shaped aperture **216** diameter is from 0.7 to 0.78 inches as measured from a corner of the aperture, through the center of the disc clamp **210**, to farthest edge of the opposite screw mounting hole **212** as shown in FIG **5**. Within the optimal range, the model indicates that a diameter is 0.77 inches achieves the most substantially uniform distribution of clamping force.

Another aspect of the invention is described below with reference to the cross-sectional view of the disc clamp **210** in FIG. **6**. The annular rim portion **240** of the disc clamp **210** has a stiffening portion **332**. The stiffening portion **332** has a stiffening rib **334** adjacent and interior to the contact rib **330**. The stiffening rib **334** serves the purpose of increasing the stiffness of the contact rib **330**, thus further reducing non-uniform distribution of the clamping force while in contact with the disc **108**.

A third aspect of the invention is shown in cross-sectional view of the disc clamp **210** presented in FIG. **7**. A dampening ring **400** of visco-elastic material is contained within or beneath the stiffening rib **334**. The dampening ring **400** serves the purpose of dissipating vibrational energy in the disc clamp **210** from external shocks to the disc drive **100** or from disc drive operation. The dampening ring **400** eliminates "ringing" in the disc clamp **210** by dampening vibrations of frequencies including the disc clamp's resonant harmonics. FIG. **7** shows a toroidal, or O-ring shaped, dampening ring **400** having a circular cross section. However, any appropriate cross sectional shape may be used.

In summary, a preferred embodiment of the invention may be viewed as a disc clamp (such as **216**) for fastening a data disc (such as **108**) to a disc spin motor hub (such as **230**). The disc clamp (such as **210**) has a generally circular disc shaped body having a concentric central portion (such as **218**) and an annular rim portion (such as **240**). The central portion (such as **218**) defines a generally triangular central aperture (such as **216**) therethrough and has spaced apertures (such as **212**) around the central aperture (such as **216**) for mounting the disc clamp (such as **210**) to a spin motor hub (such as **230**). The rim portion (such as **240**) forms an annular contact rib (such as **330**) through which a distributed clamping force is applied to the data disc (such as **108**).

Preferably, the disc clamp (such as **210**) has three spaced apertures (such as **212**) around the central aperture (such as **216**). In a preferred embodiment, the triangular central aperture (such as **216**) generally has the shape of an equilateral triangle wherein the corners of the central aperture (such as **216**) are curved and have a radius substantially equal to that of the radius of the disc clamp (such as **210**). The disc clamp (such as **210**) has an outer diameter of 1.22 inches, an engagement

surface or annular contact rib (such as **330**) diameter of 1.125 inches, and a triangular shaped aperture (such as **216**) diameter between 0.7 to 0.78 inches and preferably 0.77 inches as measured from a corner of the aperture, through the center of the disc, to farthest edge of the opposite screw mounting hole (such as **212**).

The invention also may be viewed as a disc clamp (such as **210**) having a generally circular disc shaped body having an annular rim portion (such as **240**) having an annular contact rib (such as **330**), a concentric annular stiffening portion (such as **332**) adjacent to the rib (such as **330**), and a central portion (such as **218**). Preferably, the stiffening portion (such as **332**) forms a second annular rib (such as **334**) stiffening the rim portion (such as **240**). In a preferred embodiment the central portion (such as **218**) has a central aperture (such as **216**) therethrough that is substantially triangular shaped and three spaced apertures (such as **212**) around the central aperture (such as **216**) each for receiving one of three fasteners.

Alternatively, the invention also may be viewed as a disc clamp (such as **210**) having a generally circular disc shaped body having an annular rim portion (such as **240**) and a central portion (such as **218**), wherein a dampening ring (such as **400**) is fixed to the annular rim portion (such as **240**) to dampen vibrations in the disc clamp (such as **210**). Preferably, the dampening ring (such as **400**) is toroidally shaped, made of a visco-elastic material and is positioned against the stiffening portion (such as **240**) to adsorb vibrations in the disc clamp (such as **210**). In the preferred embodiment, the dampening ring (such as **400**) is fixedly held within a stiffening rib (such as **334**) in the rim portion (such as **240**) of the disc clamp (such as **210**).

It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While a presently preferred embodiment has been described for purposes of this disclosure, various changes and modifications may be made which are well within the scope of the present invention. For example, in alternative embodiments the dampening ring **400** can contact the surface of the disc **108** or may be placed within the contact rib **330** rather than the stiffening rib **334**. The dampening ring **400** may be fixed in place by any means including, but not limited to, adhesive, press fitting or molding it in place. The corners **214** of the triangular central aperture **216** can be utilized as

spanner slots to assist in placement and mounting of the disc clamp **210** to the spindle motor **106**. The stiffening rib **334** or an addition stiffening rib **334** may be located exterior to the annular contact rib **330**. Numerous other changes may also be made which will readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the invention disclosed and as defined in the appended claims.

CLAIMS

What is claimed is:

1. A disc clamp for fastening a data storage disc to a disc spin motor hub in a disc drive, the disc clamp comprising:

a generally circular disc shaped body having an annular rim portion and a concentric central portion, the rim portion having an annular rib for pressing against the data disc, the central portion defining a generally triangular central aperture therethrough and spaced mounting apertures around the central aperture for receiving fasteners to fasten the disc clamp to a spin motor hub and apply a distributed clamping force through the annular rib to a data storage disc carried on the spin motor hub.

2. The disc clamp according to claim 1 wherein the triangular central aperture generally has the shape of an equilateral triangle.

3. The disc clamp according to claim 1 wherein the corners of the generally triangular central aperture are curved.

4. The disc clamp according to claim 3 wherein there are three spaced apertures around the central aperture each for receiving one of three fasteners.

5. The disc clamp according to claim 4 wherein each of the curved corners of the central aperture has a radius.

6. The disc clamp according to claim 5 wherein the radius of each of the curved corners of the central aperture is substantially the same as the radius of the three spaced apertures.

7. The disc clamp according to claim 5 wherein the radius of the corners of the central aperture is substantially equal to that of the radius of the disc clamp.

8. The disc clamp according to claim 1 wherein the corners of the central aperture are located such that the distance from the outermost edge of the central aperture to the rim of the disc clamp is substantially the same as the distance from an outermost edge of the mounting apertures to the rim of the disc clamp.

9. The disc clamp according to claim 5 wherein the disc clamp has an outer diameter of about 1.22 inches, an engagement surface or contact diameter of 1.125 inches, and a triangular shaped aperture diameter of 0.7 to 0.78 inches as measured from a corner of the aperture, through the center of the disc, to a farthest edge of an opposite screw mounting hole.

10. The disc clamp according to claim 9 wherein the disc clamp has a triangular shaped aperture diameter of 0.77 inches as measured from a corner of the aperture, through the center of the disc, to the farthest edge of the opposite screw mounting hole.

11. A disc clamp for fastening a data disc to a spin motor hub in a disc drive, the disc clamp comprising:

a generally circular disc shaped body having a central portion, an annular rim portion around the central portion having an annular rib having an annular surface for contacting a data disc, and a concentric annular stiffening portion adjacent to the rib forming a second annular rib stiffening the rim portion, the central portion having spaced mounting apertures around a center of the disc clamp for receiving fasteners therethrough for fastening the disc clamp to the spin motor hub.

12. The disc clamp according to claim 11 wherein the central portion has a central aperture therethrough.

13. The disc clamp according to claim 12 wherein the central aperture has a substantially triangular shape.

14. A disc clamp for fastening a data disc to a spin motor hub in a disc drive comprising:

a generally circular disc shaped body having an annular rim portion and a central portion, the central portion having spaced mounting apertures spaced around the center of the disc clamp for receiving fasteners for fastening the disc clamp to a spin motor hub; and

a dampening ring adapted to fit between the annular rim portion and a data disc.

15. The disc clamp according to claim 14 wherein the dampening ring is made of a visco-elastic material positioned against the stiffening portion to adsorb vibrations in the disc clamp.

16. The disc clamp according to claim 14 wherein the dampening ring is toroidally shaped.

17. The disc clamp according to claim 14 wherein the dampening ring is fixedly held within a rib in the rim portion of the disc clamp.

18. A disc clamp device for fastening a data disc to a drive motor hub comprising:

a disc shaped body; and

a means on the disc clamp for distributing discretely applied clamping force substantially uniformly to the data storage disc.

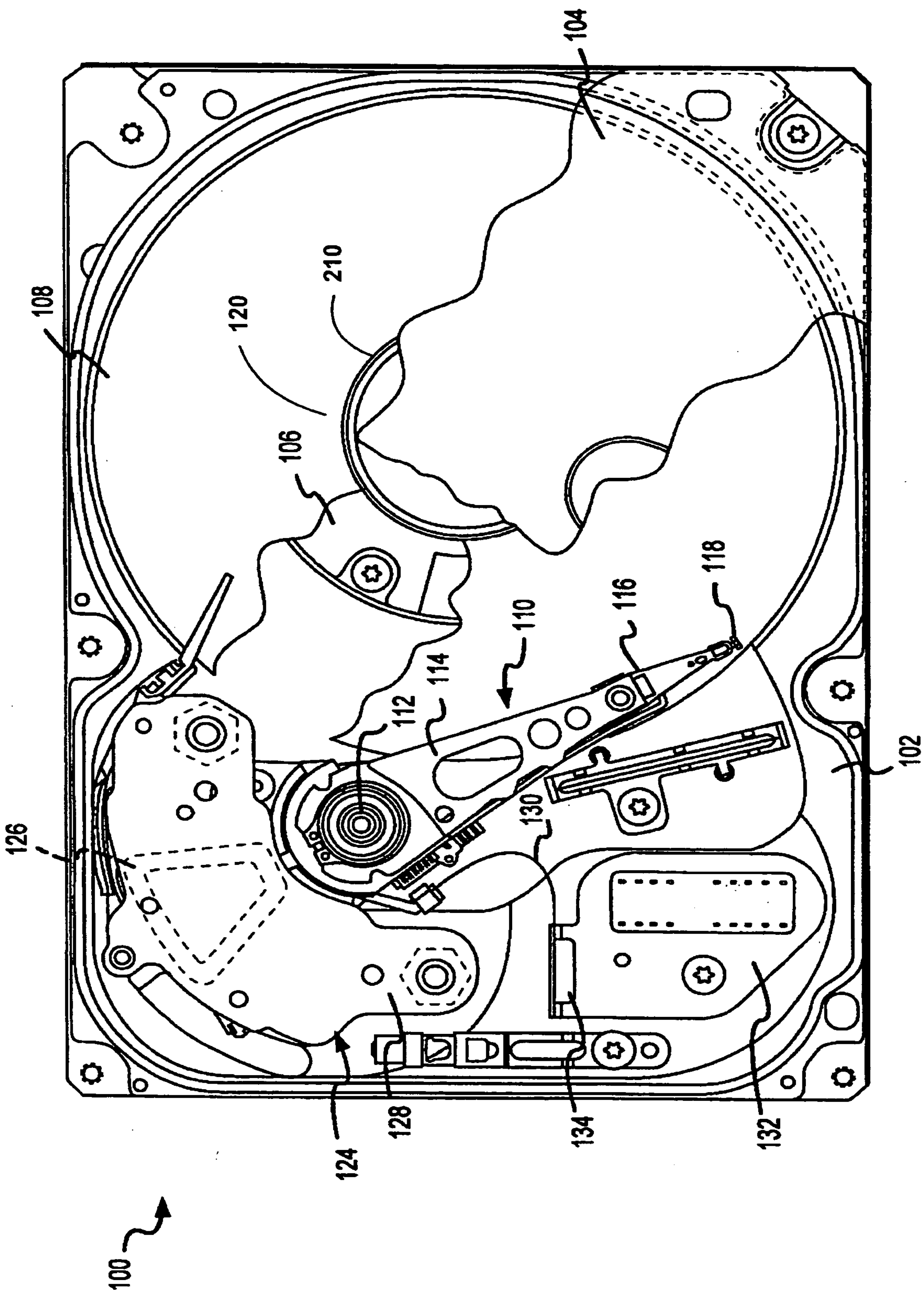

104
108
210
120
106
110
116
118
114
112
126
130
102
124
128
134
132
100

FIG.1

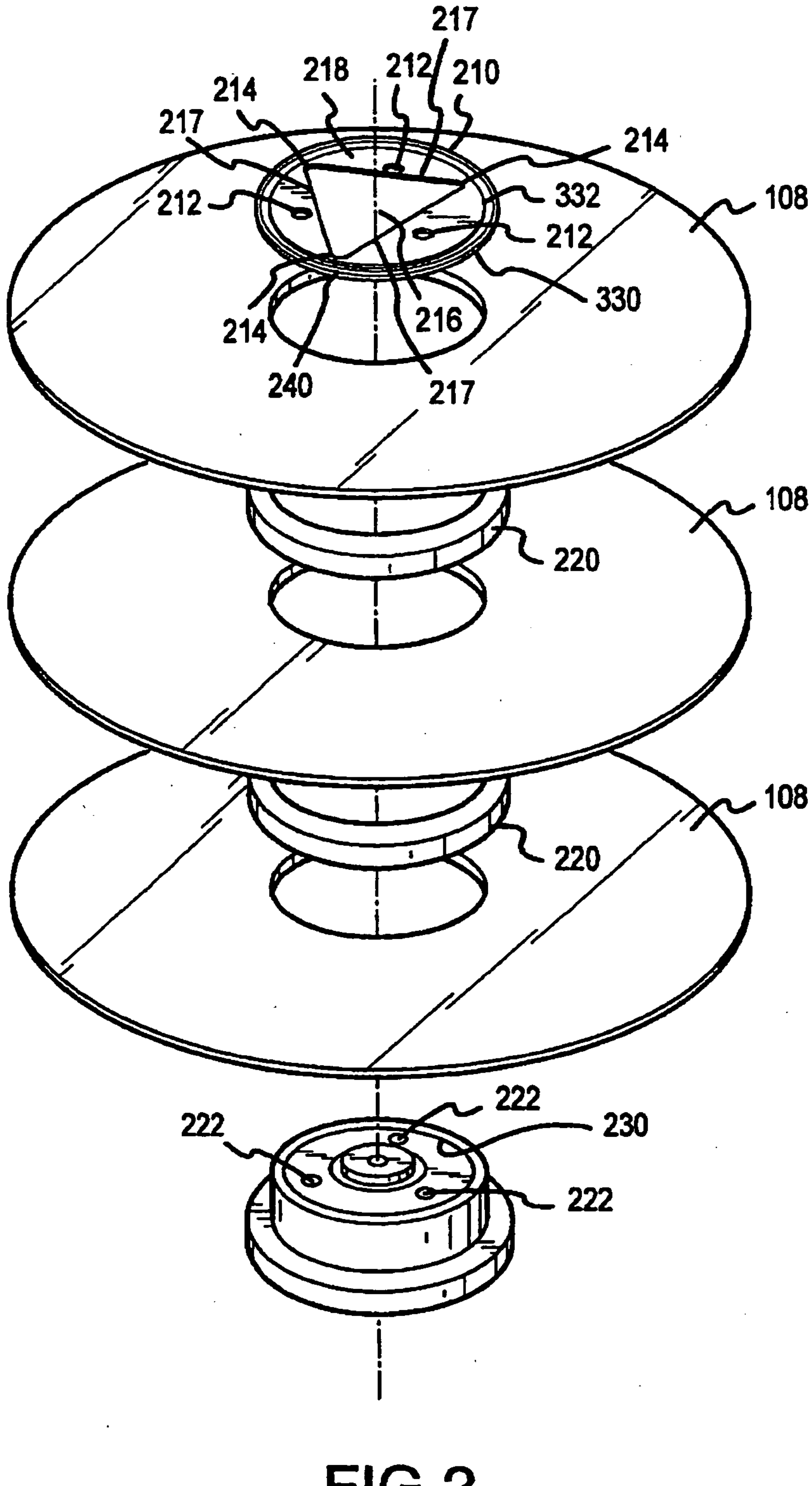

217
218
212
210
214
217
214
212
332
108
212
330
216
214
240
217
108
220
108
220
222
222
230
222

FIG.2

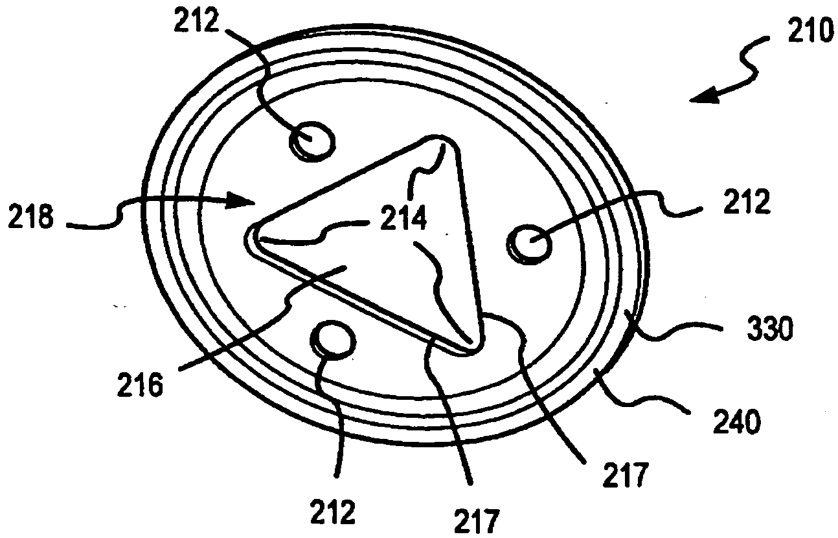


FIG.3

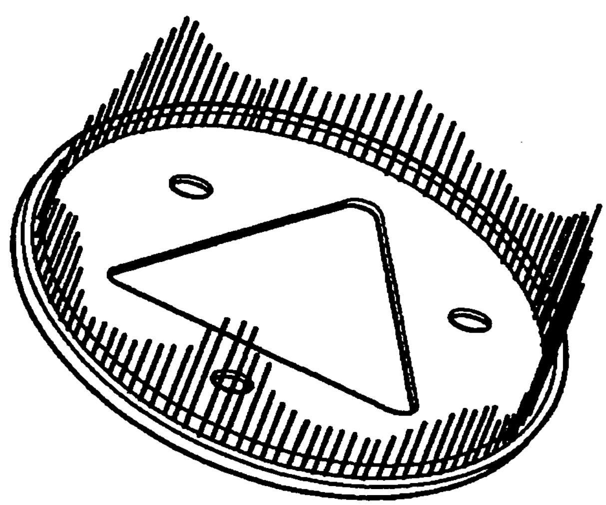


FIG.4

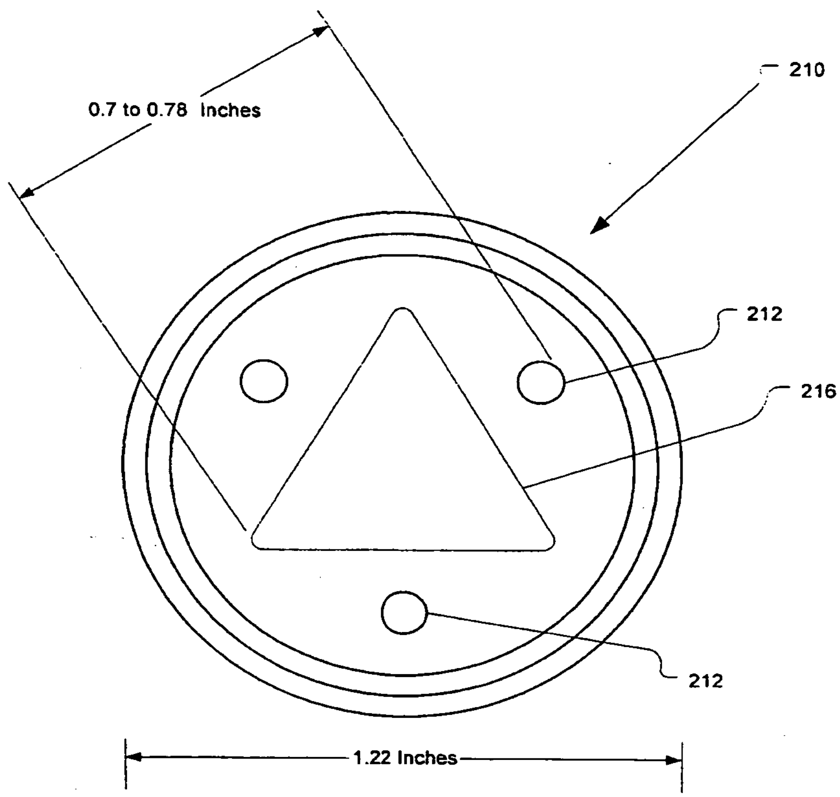


FIG. 5

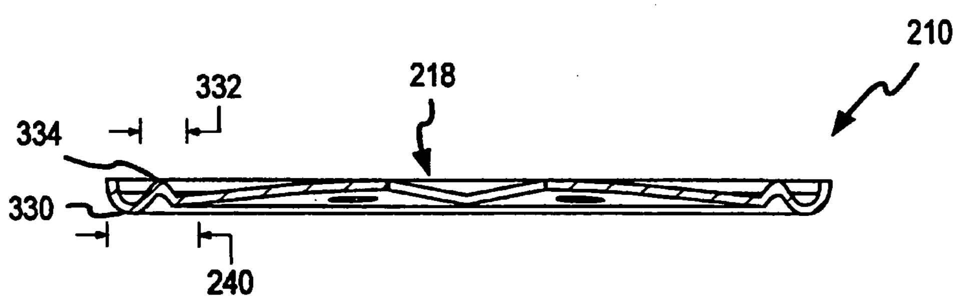


FIG.6

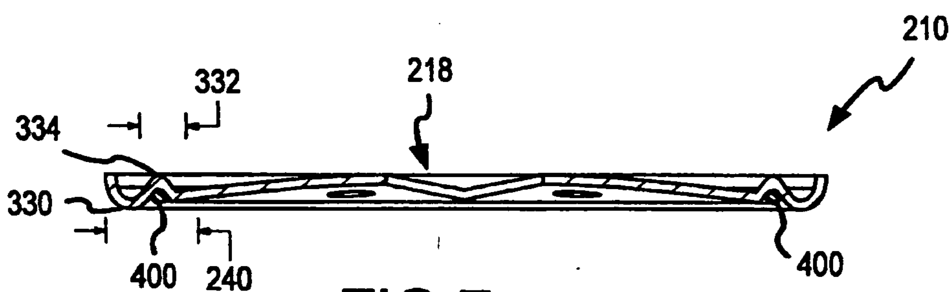


FIG.7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/27621

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11B17/038 G11B17/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 528 434 A (BRONSHVATCH EFIM ET AL) 18 June 1996 (1996-06-18) abstract; figures	11,12,18
A	column 5, line 19 -column 6, line 48 ---	1,14
X	WO 95 13614 A (CONNER PERIPHERALS INC) 18 May 1995 (1995-05-18) abstract; figures	11,12,18
A	page 8, line 27 -page 11, line 36 ---	1,14
X	EP 0 366 311 A (IBM) 2 May 1990 (1990-05-02) abstract; figures	14,16,18
A	column 2, line 15 -column 3, line 20 ---	1,11
X	US 5 333 080 A (RIDINGER ERNST W ET AL) 26 July 1994 (1994-07-26)	18
A	abstract; figures ---	1,11,14

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 January 2001	15/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Declat, M

1

INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/US 00/27621

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 872 682 A (IDE MITSURU ET AL) 16 February 1999 (1999-02-16) abstract; figures	1,2,11, 14,18
X	GB 2 230 891 A (SEAGATE TECHNOLOGY) 31 October 1990 (1990-10-31)	18
A	page 3, line 6 - line 29; figures	1,11,14
X	US 5 790 345 A (ALT ROBERT A) 4 August 1998 (1998-08-04)	18
A	abstract; figures	1,11,14
A	EP 0 573 250 A (SEAGATE TECHNOLOGY) 8 December 1993 (1993-12-08) abstract; figures	1,4,11, 14,18
P,X	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 06, 22 September 2000 (2000-09-22) & JP 2000 076762 A (MITSUBISHI CHEMICALS CORP), 14 March 2000 (2000-03-14) abstract; figure	14,16,18
E	WO 00 63902 A (SEAGATE TECHNOLOGY LLC) 26 October 2000 (2000-10-26) page 6, line 15 -page 7, line 5; figures 2-6	1,3-5,18

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte ɔnal Application No
PCT/US 00/27621

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5528434 A	18-06-1996	NONE	
WO 9513614 A	18-05-1995	US 5490024 A	06-02-1996
		DE 69423774 D	04-05-2000
		DE 69423774 T	27-07-2000
		EP 0728356 A	28-08-1996
		JP 2763680 B	11-06-1998
		JP 9503331 T	31-03-1997
EP 0366311 A	02-05-1990	US 4918545 A	17-04-1990
		DE 68920114 D	02-02-1995
		DE 68920114 T	29-06-1995
US 5333080 A	26-07-1994	NONE	
US 5872682 A	16-02-1999	JP 3023761 B	21-03-2000
		JP 8153362 A	11-06-1996
GB 2230891 A	31-10-1990	US 5274517 A	28-12-1993
US 5790345 A	04-08-1998	JP 10172258 A	26-06-1998
EP 0573250 A	08-12-1993	US 5295030 A	15-03-1994
		DE 69313516 D	09-10-1997
		DE 69313516 T	08-01-1998
		HK 1002638 A	04-09-1998
		JP 2634368 B	23-07-1997
		JP 6139674 A	20-05-1994
		SG 48086 A	17-04-1998
JP 2000076762 A	14-03-2000	NONE	
WO 0063902 A	26-10-2000	NONE	